Fuels

Funding Schedule by Activity

(dollars in thousands)

	FY 2004	FY 2005	FY 2006	$ Change	% Change
Fuels					
Transportation Fuels and Chemicals	21,340	23,470	22,000	-1,470	-6.3%
Solid Fuels and Feedstocks	5,820	5,916	0	-5,916	-100.0%
Advanced Fuels Research	3,216	2,761	0	-2,761	-100.0%
Total, Fuels	30,376	32,147	22,000	-10,147	-31.6%

Description

The mission of the Fuels program is to create public benefits by conducting the research necessary to promote the transition to a hydrogen economy. Research will target reducing costs and increasing efficiency of deriving hydrogen from coal feedstocks as part of the President's Hydrogen Fuel Initiative.

Benefits

Achievement of Hydrogen from Coal RD&D goals within the Hydrogen Fuel Initiative will help the U.S. improve energy security and achieve a sustainable hydrogen economy. This will be done by reducing imports of oil and using abundant domestic coal reserves. U.S. coal reserves nearly equal to three quarters of the total proved world conventional oil reserves (on an energy equivalent basis) and represent hundreds of years of supply at today's domestic consumption rate.

In addition, the use of hydrogen from coal can reduce environmental concerns associated with energy use in automotive and stationary power applications through the clean production of hydrogen from coal in tandem with carbon sequestration. Gasification technologies have shown the potential to produce clean synthesis gas from coal with virtually zero pollutant emissions. Carbon sequestration technologies are providing the means to cost-effectively use concentrated CO_2 streams, for example, in enhanced oil recovery. Finally, the use of coal-derived hydrogen in fuel cells can provide efficient, emission-free power from hydrogen in both automotive and stationary power applications. The emissions and energy benefits that can be realized with successful Hydrogen from Coal RD&D to enable low-cost hydrogen from coal production with sequestration, and use in fuel cell vehicles, compared to internal combustion engine vehicles are discussed below.

Benefits have been evaluated by Fossil Energy (FE) staff and consultants using a well-to-wheel analysis prepared by Argonne National Laboratory (ANL) (GREET model) and expanded to include coal. The analysis conservatively assume that in 2025 20% of all fuel cell vehicle (FCV) hydrogen demand in the United States is produced from coal based on preliminary analyses performed by ANL that addressed resource availability and costs to produce hydrogen. The FE staff and consultant analysis shows that by 2025, using the hydrogen fuel cell vehicle market penetration detailed in DOE's Hydrogen Posture Plan, annual hydrogen demand will reach 1.5 quadrillion British thermal units (10^{15} Btu or 1.5 quads) that will

power 50.9 million light-duty fuel cell vehicles, 10.2 million of which (20%) are assumed to be powered by hydrogen from coal for this analysis.

In 2025, this scenario analysis estimates that hydrogen from coal and use in FCVs will save 370 thousand barrels per day of imported oil, 0.15 trillion cubic feet of imported natural gas per year, while increasing coal consumption by over 22 million tons per year, an amount equal to just over 2% of 2001 annual coal demand. These results represent our best judgments and FE continues the analysis with its consultants and NETL staff to ensure their consistency.

In addition, the analysis estimates that this technology will reduce the cost of our Nation's fossil fuel consumption by almost $4 billion per year, reduce nitrogen oxides (NO_x) emissions by 20 thousand metric tons per year, sulfur oxides (SO_x) emissions by 5.3 thousand metric tons per year and CO_2 emissions by 67 million tons if CO_2 from coal is sequestered when hydrogen is produced. FCVs are assumed 2.5 times more efficient than internal combustion engine vehicles (ICEVs). A modified Argonne National Laboratory GREET 1.6 model was used to estimate energy use and emissions associated with resource extraction, conversion and hydrogen consumption in FCVs, while the Energy Information Administration's (EIA) Annual Energy Outlook (AEO) 2004 was used for year 2025 fossil fuel values ($2002 basis).

Background

Currently, the United States imports approximately 11 million barrels per day of petroleum crude and finished products (55% of consumption). By 2025 imports are projected to rise to 19.8 million barrels per day of crude and refined products (68% of consumption). Coal-derived hydrogen can be an important part of a strategy to diversify and expand our domestic fuel resource base, reduce emissions from the transportation sector, and help limit our reliance on imported oil.

In addition to energy security issues, major challenges facing transportation are urban and regional air pollution and emissions of greenhouse gases. EIA 2000 data indicates that of man-made emissions, the U.S. transportation sector is responsible for nearly 80 percent of the carbon monoxide (CO), over one half of the nitrogen oxides (NO_x), and 40 percent of the volatile organic compounds (VOC). Vehicles are responsible for about 35% of the U.S. energy sector's carbon dioxide production. As the Nation transitions toward advanced engine platforms, ultra-low emission vehicles and eventually to near-zero emission vehicles, such as through the Administration's FreedomCAR partnership, the demand for hydrogen will increase dramatically. The Administration's Hydrogen Fuel Initiative is a coordinated effort among the Department's Offices (EERE, FE, NE, Science) to provide the technology for the private sector to meet the anticipated hydrogen demand and the infrastructure needed to provide the hydrogen to the end-user. Our large domestic resources of coal can provide high volume, low-cost, hydrogen for fuel cells in the longer term.

Research will address the development of technologies to produce, distribute and store hydrogen as an affordable, safe fuel for consumers. Specifically, this research activity will encompass a technology envelope that includes the separation of hydrogen from mixed gas streams and provides the hydrogen to fuel cells and other end-use systems. In FY 2006, research will continue to target the development of technologies capable of economically producing large quantities of pure hydrogen from coal-derived synthesis gas, which will enable hydrogen from coal feedstocks to play a major role in the transition to sustainable hydrogen based energy systems.

Centralized production of hydrogen from coal feedstocks will produce a concentrated stream of carbon dioxide, which will facilitate its economic capture and sequestration. There are two routes to supplying hydrogen from these advanced coal gasification facilities. A portion of the hydrogen can be separated from the mixed gas stream (i.e. synthesis gas) which is produced during the gasification process and then stored for distribution. The other alternative is to produce, via synthesis gas conversion processes, zero-sulfur, high hydrogen content coal-derived fuels that can be moved through the present distribution system, then reformed at facilities in close proximity to the customer or directly on-board the vehicle.

Detailed Justification

(dollars in thousands)

	FY 2004	FY 2005	FY 2006
Transportation Fuels and Chemicals	**21,340**	**23,470**	**22,000**

This program conducts laboratory and process research to develop advanced technology for producing ultra clean fuels and hydrogen from coal by use of gasification technology possibly with coproduction of electricity and other products.

- **Reactor/Process Development** **1,491** **0** **0**

  No funding is requested for this activity in FY 2006 and FY 2005.

  In FY 2004, continued the coproduction feasibility studies to establish optimal marketable products and plant configurations for specific facilities for production of clean synthesis gas derived liquid fuels, clean electric power and heat based on coal gasification.

- **Syngas Membrane Technology** **5,965** **5,174** **0**

  In FY 2006 no funds are requested for this activity.

  In FY 2005, conduct work on novel syngas ceramic membrane development targets for the production of environmentally superior liquid fuels and hydrogen. *Participant: APCI*

  FY 2004 funding continued exploratory research activities of novel conversion concepts of promising chemical and small-scale physical conversion technology innovations. Continued research and development of a novel syngas ceramic membrane technology to enhance Fischer-Tropsch (F-T) gas conversion for environmentally superior liquid fuels and hydrogen. Conducted fundamental supporting fuels research at NETL. *Participants included: APCI, NETL, LANL, Univ. Of Alaska, Canmet, Praxair.*

- **Ultra Clean Fuels** **8,786** **976** **0**

  In FY 2006 no funds are requested.

  In FY 2005, conduct studies to establish the usability of the small footprint syntroleum pilot plant in Tulsa, Oklahoma to process coals to produce a synthesis gas for catalytic conversion to zero

sulfur, high cetane number Fishcer-Tropsch liquid transportation fuels. *Participant: ICRC/Syntroleum.*

FY 2004 funding continued cost-shared industrial research for the development of ultra-clean fuels technology for fossil resources (natural gas, petroleum, coal). Projects will continue to develop advanced technology for the production of natural gas derived synthesis gas and ultra-clean fuels. Funding will also be provided for the completion of a novel, molten metal reactor for production of hydrogen with a concentrated stream of carbon dioxide for capture from coal-based feedstock.

- **Hydrogen from Coal Research**..... **4,879** **17,085** **21,780**

In FY 2006, continue research for the development of novel technology for: 1) separating hydrogen from mixed gas streams including polishing technology to remove remaining impurities prior to utilization; 2) producing high hydrogen content coal-derived liquids for subsequent reforming at distributed generation facilities, 3) storing and delivering hydrogen/liquid hydrogen carriers; 4) utilizing hydrogen in non-fuel cell powered applications; 5) small-scale hydrogen production systems with CO_2 capture/sequestration capability; and utilize NETL's computation science expertise to provide the technical foundation upon which to facilitate the development of advanced system components associated with the production, delivery, storage and utilization of hydrogen from coal; and initiate systems engineering studies: 1) to develop more efficient and less costly concepts for liquid fuels reforming; and 2) to determine optimum strategies for scale-up of advanced separation membrane modules.

In FY 2005, perform research for the development of novel technology for: 1) separating hydrogen from mixed gas streams (continuation) including polishing technology to remove remaining impurities prior to utilization (new); 2) producing high hydrogen content coal-derived liquids for subsequent reforming on-board vehicles and/or at distributed generation facilities (continuation); 3) storing and delivering hydrogen/liquid hydrogen carriers (continuation); 4) utilizing hydrogen in non-fuel cell powered applications (new); 5) small-scale hydrogen production systems with CO_2 capture/sequestration capability (new), and utilize NETL's computation science expertise to provide 6) the technical foundation upon which to facilitate the development of advanced system components associated with the production, delivery, storage and utilization of hydrogen from coal. Conduct a study of hydrogen pathways for the production from low rank coal.

In FY 2004, FE began hydrogen from coal initiative by competitive procurement. Identified appropriate organizations to (1) establish the feasibility of emerging alternate coal-based hydrogen technologies, (2) investigate advanced separation technologies, and (3) utilize a combination of experimental and advanced computational methods to determine optimal reaction chemistries for producing hydrogen from coal-derived fuels.

Participants include: SouthWest Research Institute, U. Of Calif.-Davis, Gas Technology Institute, Media & Process Technology, Ohio State Univ, Wright-Patterson AFB, Eltron Res., Inc., Oak Ridge National Lab, Los Alamos National Lab, Argonne National Lab, NETL, UNDEERC, TBD.

(dollars in thousands)

	FY 2004	FY 2005	FY 2006
▪ **Program Support**.....	**219**	**235**	**220**
Fund technical and program management support.			
Solid Fuels and Feedstocks.....	**5,820**	**5,916**	**0**
Research provided advanced technologies to produce clean high value carbon products from coal such as high purity carbon electrodes and specialty graphite. Composite fuels comprised of coal and waste biomass for greenhouse gas reduction and separation technology for producing additional clean coal from wastes.			
▪ **Premium Carbon Products**.....	**966**	**976**	**0**
No funding requested in FY 2006.			
In FY 2005 and FY 2004, conduct work on development of novel processes to produce high value graphite, activated carbon, carbon fibers for high strength materials, carbon foams for military applications and carbon electrodes for batteries and fuel cells. *Participants include: Penn State.*			
▪ **Advanced Separation**	**2,874**	**2,928**	**0**
No funding requested in FY 2006.			
In FY 2005 and FY 2004, conduct work on developing processes for reclamation of coal fines to monetize coal from waste coal sites and mitigate potential environmental issues associated with these sites; and to develop solid-liquid coal separation processes that have crosscutting applicability the mineral industry. *Participants include: Virginia Tech, WVU.*			
▪ **Coal-Derived Jet Fuels**.....	**1,920**	**1,953**	**0**
No funding requested in FY 2006.			
In FY 2005, conduct work on the FY 2004 research and development to determine the technical requirements and cost implications of integrating the coal-derived jet fuel production and by-product processes into refinery operations. *Participant: Penn State*			
▪ **Program Support**.....	**60**	**59**	**0**
Fund technical and program management support.			
Advanced Fuels Research.....	**3,216**	**2,761**	**0**
Provide the scientific underpinning for the development of advanced ultra clean liquid fuels and hydrogen technology from coal.			

(dollars in thousands)

	FY 2004	FY 2005	FY 2006
▪ **Advanced Research**	**3,183**	**2,733**	**0**

No funding is requested for this activity in FY 2006.

In FY 2005, conduct work on supporting research that will facilitate the development of high-efficiency, affordable processes for converting coal to high value fuels, including hydrogen and hydrogen precursors; and to develop a coal extraction process that provides precursor chemicals suitable for production of premium coal-derived materials.

FY 2004 funding is to provide supporting science that will facilitate the development of high-efficiency, affordable processes for converting coal to high value fuels, including hydrogen and hydrogen precursors; and to develop a coal extraction process that provides precursor chemicals suitable for production of premium coal-derived materials. These products are intended to augment and eventually replace carbon products derived from petroleum or coke-oven byproducts. *Participants include: Univ of Kentucky et at, WVU*

▪ **Program Support**	**33**	**28**	**0**

Fund technical and program management support.

Total, Fuels	**30,376**	**32,147**	**22,000**

Explanation of Funding Changes

	FY 2006 vs. FY 2005 ($000)
Transportation Fuels and Chemicals	
▪ **Syngas Membrane Technology**	
Discontinued research and development of a novel syngas ceramic membrane technology produce synthesis gas for environmentally superior liquid fuels and hydrogen since these are improvements to commercial technology which industry could do on their own	-5,174
▪ **Ultra Clean Fuels**	
Conclude studies to establish the usability of the small footprint syntroleum pilot plant in Tulsa, Oklahoma to process coals to produce a synthesis gas for catalytic conversion to zero sulfur, high cetane number Fishcer-Tropsch liquid transportation fuels	-976

	FY 2006 vs. FY 2005 ($000)
▪ **Hydrogen from Coal Research** Continue Hydrogen from Coal Research to developed improved, novel technology for the production of hydrogen and its separation, delivery, storage and utilization at lower cost including the initiation of studies for advanced concepts for simultaneous separation of carbon dioxide, H_2S and other trace components from hydrogen	+4,695
▪ **Program Support**	-15
Total, Transportation Fuels and Chemicals	**-1,470**
Solid Fuels & Feedstocks	
▪ **Premium Carbon Products** Discontinue development of novel processes to produce high value carbon materials because of lower priority	-976
▪ **Advanced Separation** Discontinue development of processes for separations to reclamation of coal fines, mitigate potential environmental issues associated with these sites; and development of solid-liquid coal separation processes that have crosscutting applicability to the mineral industry because of lower priority	-2,928
▪ **Coal-Derived Jet Fuels** Discontinue research and development to determine the technical requirements and cost implications of integrating the coal-derived jet fuel production and by-product processes into refinery operations because of lower priority	-1,953
▪ **Program Support**	-59
Total, Solid Fuels & Feedstocks	**-5,916**
Advanced Fuels Research	
▪ Conclude science for converting coal to high value fuels, including hydrogen and hydrogen precursors and coal extraction process that provides precursor chemicals suitable for production of premium coal-derived materials	-2,733
▪ **Program Support**	-28
Total, Advanced Fuels Research	**-2,761**
Total Funding Change, Fuels	**-10,147**